NOAA Science Advisory Board Review of the Cooperative Institute for Research in Environmental Sciences

Executive Summary

A panel of seven scientists, appointed by the National Oceanic and Atmospheric Administration (NOAA), Science Advisory Board (SAB), carried out a review of the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado (CU) Boulder, September 24-27, 2002. The panel met with both the scientists and administrators in CIRES and the NOAA laboratories with which cooperative research occurs. This report presents the findings of the review. Discussed in this report are the strengths of the CIRES research efforts as well as areas of the CIRES program in which improvement and further study are recommended. The ongoing and planned research of the CIRES/NOAA groups is judged by the panel to be of the highest quality. The strong and useful interaction between CIRES and NOAA scientists and the success of their research efforts are facilitated by several favorable features of the relationship: 1) The excellent leadership of the CIRES administration and the strong support of the University of Colorado administration 2) The cooperative format of the current CIRES/NOAA research agreement. 3) The constructive catalytic role that CIRES plays in the NOAA research. 4) The unique position of CIRES/NOAA efforts to face crisis research. 5) The efficient use of government funding which the relation provides. 6) The unique strength of the Boulder area in the environmental science research institutions. 7) The education in environmental issues that CIRES provides teachers, students and the general public. 8) The diverse input in environmental problem solving which brings the full compliment of experts in the sciences and the non-science disciplines together to provide the decision makers with the necessary information to facilitate implementation of any planning and legislation that might be required to mediate and solve given science oriented problems related to the environment.

The panel identified some areas in the CIRES/CU/NOAA relationship which require some degree of attention: 1) The perceived and real differences in status of government employees and CIRES employees that often work side by side on mutual problems. 2) Traditional rigidity in the faculty structure that remains within the University of Colorado. 3) Considerations of contract versus grant research and the need to streamline the process by which work tasks are established and funds are transferred. 4) Extent of institutional support for CIRES. 5) Increasing needs for additional biological scientists in many of the CIRES research programs. 6) Improvement of the employee reward systems. 7) Importance of a proposed Environmental Technology Center within CIRES.

The panel concludes that the current structure of CIRES is diverse and flexible, well suited to maintain a strong interaction with the NOAA laboratories and to respond to implementation and operational needs of NOAA.

Report of the NOAA Science Advisory Board Review of the Cooperative Institute for Research in Environmental Sciences

September 25-27, 2002

I. Introduction

A. Composition of the Review Panel:

Dr. Jack G. Calvert, Senior Scientist Emeritus, NCAR, Boulder, CO, Chair of Panel (Now Scientific Visitor with Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN.)
Dr. Vera Alexander, Dean of the School of Fisheries and Ocean Sciences and Professor of Marine Science, University of Alaska Fairbanks; Representative of the NOAA Science Advisory Board
Dr. Walter F. Dabberdt, Director, Strategic Research, Vaisala, Boulder, CO
Dr. Jerry Mahlman, Senior Research Associate, NCAR, Advanced Study Program, Boulder, CO
Dr. Wade R. McGillis, Associate Scientist, Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA
Dr. William H. Prescott, Geophysicist, U.S. Geological Survey, Menlo Park, CA (Now with UNAVCO, Inc., Boulder, CO.)
Dr. Kelly T. Redmond, Deputy Director and Regional Climatologist, Western Regional Climate Center, Desert Research Institute, Reno, NV

B. Format of the CIRES/NOAA Program Review

About one week before the formal review, the review panel was provided by mail with an extensive and useful document describing all aspects of the CIRES/NOAA cooperative research efforts. The panel convened for the review at the CIRES headquarters at the University of Colorado in Boulder, CO during the period September 24-28, 2002. The detailed schedule of the review activities of the panel is summarized in Appendix A of this report, and a brief description of these is given here. An oral and visual overview of the CIRES/NOAA was given to the panel on the first day of the review by the CIRES Director, Susan Avery, during which the nature of the CIRES research organization, its goals, past accomplishments, and future plans were outlined. Two poster sessions were arranged for the panel during which CIRES and NOAA scientists described representative studies using both graphical and oral presentations, one-on-one, CIRES/NOAA scientist with a given panel member. Thirty-seven different research projects were discussed in the various areas of research interest: Advanced Observing and Modeling Systems (8 posters); Climate System Variability (7 posters); Geodynamics (5 posters); Integrating Activities (5 posters); Planetary Metabolism (5 posters); Regional

Processes (7 posters). The adopted presentation methods of the host organization were reasonably successful in achieving the difficult task of describing to the review panel many of the extensive research efforts of the CIRES/NOAA research within the relatively short time frame of the review.

The panel had meaningful discussions related to the NOAA-CIRES management and scientific interactions with several key administrative officials important in the CIRES/NOAA cooperative efforts. Discussions were held with the Vice President for Research and Dean of the Graduate School, University of Colorado, Dr. Carol Lynch, and the directors of the several NOAA Laboratories. Group meetings were also held with the key committees involved in the CIRES/NOAA cooperative research efforts: the Executive Committee; Council of Fellows, and the Members of the Council.

The discussions with CIRES and NOAA scientists and administrators together with some deliberations between Panel members resulted in written comments of each panel member related to the CIRES/NOAA cooperative effort. These were provided on disk to the Chair of the review panel who organized the panel writings and discussions into a preliminary report. The preliminary report was circulated to each panel member for corrections, additions and comments by each panel member, and after iteration of this procedure, this final report was prepared.

C. The Goals and Structure of CIRES

The well-posed central question around which CIRES research is focused appears to be an excellent choice: *How well can we understand and predict the effects of natural and anthropogenic perturbations on the earth system and how can we use this knowledge to protect the health of the earth system?* CIRES is an institute of approximately 500 scientists, faculty, research assistants and associates, and support and administrative staff. CIRES intellectual leadership is provided by the Council of Fellows, a body of nearly 50 persons comprised of 27 university department chairs and senior researchers and faculty, 15 senior NOAA scientists, four emeritus Fellows, and two representatives from the Members' Council. The CIRES Members' Council is a 12-member policy and advisory body comprised of representatives from six CIRES components. The CIRES Executive Committee comprises ten members from management, administration, the Fellows, and staff. It is responsible for matters pertaining to day-to-day management of the institute.

D. The NOAA-CIRES-CU Partnership

The panel examined the nature and effectiveness of the partnership among NOAA, the University and CIRES. In many ways, this relationship has the strengths inherent in the three-legged stool with each party complementing and strengthening the other. NOAA is able to extend its breadth and deepen its existing strengths because of the availability and close interactions with CIRES staff. But the value to NOAA goes beyond CIRES. Through CIRES, NOAA has effective access to a broad spectrum of complementary expertise at the university. NOAA is better able to realize its education and outreach mission objectives because of CIRES' very active and effective efforts. CIRES benefits

because it is able to better accomplish its mission of research and education for improving the understanding (and prediction) of the earth system (and its changes). Many NOAA scientists teach courses at the university helping to support CIRES education mission, and the collaborative research greatly facilitates CIRES' research objectives. The university at large also benefits in several ways: NOAA scientists teach classes; CIRES (and NOAA) investigators interact and collaborate with faculty and scientists throughout the university; and CIRES provides an effective template and mechanism for conducting and promoting interdisciplinary research at the university. CIRES is an effective earth systems integrator. In short, value of the three-party relationship greatly exceeds the sum of its respective parts.

E. Organization of this Report

The panel has organized this report to highlight the perceived strengths in the current CIRES/NOAA Cooperative Agreement (Section II) and those areas that the panel feels require some remedial action in the years ahead (Section III). In Section IV we have reviewed a few of the specific research activities which drew special attention of the review panel. In Section V the panel discusses some of the current and future features which affect the structure and administration of CIRES. Finally, a summary section VI is given which highlights specific recommendations of the panel.

II. Strengths of the CIRES/NOAA Cooperative Agreement

It is clear to the review panel that the many strengths of the CIRES/NOAA Cooperative Agreement far outweigh the areas of concern. The Agreement represents a program that offers an approach to research related to the earth system that is unique among the programs in the World today. CIRES has a high standard of excellence and is a pioneer in interdisciplinary earth system science. The present science and management teams have sustained the high quality research that is relevant to the mission of NOAA while adapting to the needs of NOAA in a timely and efficient manner. CIRES continues to be an effective and successful research organization. It has developed a technical and research environment to respond to the needs of NOAA by providing a vehicle to transition conceptions of university basic research to application and implementation of the NOAA national laboratory. CIRES also provides a unique educational framework to supply quality young scientist training for present and future NOAA needs. High quality interdisciplinary research is a difficult goal to attain. CIRES is helping to set a standard in how to conduct an interdisciplinary research program. We feel it functions remarkably well for such a large and complex enterprise in a university setting. We highlight in this section some of the many strengths of the CIRES/NOAA Cooperative Agreement.

■ *Success of the NOAA/CIRES Interaction.* The structure of CIRES is currently diverse and flexible. NOAA has relied on CIRES to be successful at its mission. This relationship should be maintained, and the interaction between NOAA and CIRES should be as a cooperative agreement. The obvious past success of the research efforts and major field

programs designed and operated by CIRES/CU/NOAA scientists encourages continuation of the unique arrangement. (See also the discussion of section V-C.)

■ *Value of Cooperative Laboratories.* The panel believes that cooperative laboratories like CIRES add great value and provide a unique research environment particularly in carrying on multidisciplinary studies. Physical co-location of the research groups within the Boulder area greatly promotes cross-fertilization and interaction between the research groups.

■ *The Importance of the Diverse Input in Environmental Problem Solving.* There is a unique opportunity of the CIRES/CU/NOAA cooperative efforts to bring the full complement of experts in the sciences and the non-science disciplines together to provide the decision makers with the necessary input to facilitate implementation of the required further study and the ultimate legislation to mediate or solve given science oriented problems related to the environment.

■ *High Quality of the CIRES/NOAA research.* The quality of the science resulting from the CIRES/NOAA interaction is judged to be very high by all of the panel. The CU environmental studies program is probably one of the best nascent programs that are emerging from academic institutions. CIRES has been crucial to the CU development as a leader in interdisciplinary and environmental research.

■ *Response of CIRES to NOAA Research Needs.* CIRES has responded to the implementation and operational needs of NOAA and has facilitated NOAA's move into the human dimensions addressing both sociopolitical and contemporary programs. CIRES has started flagship outreach programs. There has been a symbiotic relationship between CIRES, CU, and NOAA. The integration of social science can be manifested with the CU/CIRES/NOAA team

■ *CIRES Potential in Helping NOAA in Its Future Research Effort.* The subjects that CIRES is addressing now will become issues of importance to NOAA in the future. NOAA must rely heavily on such external interactions to help clarify and define its mission as that continues to evolve through the years in response to societal needs. By their nature, governmental structures are seldom well suited to grappling with problems in a holistic manner, and yet the solutions to many of these problems must entail such approaches.

■ *Catalytic Role of CIRES to NOAA Research.* The NOAA Cooperative Institutes can play an extremely helpful role in assisting and guiding NOAA in contributing to long-term solutions of complex societal problems affected by the behavior of the environment. The most difficult and challenging issues we face are heavily interdisciplinary in nature. All indications point to these problems becoming ever more complex, so that the catalytic role played by an institute such as CIRES is becoming ever more important. The review clearly illustrated the value to NOAA of a healthy Cooperative Institute/Joint Institute program. Such an arrangement features a good match between the complementary qualities of discipline-oriented research and the mission orientation of the laboratories.

■ *Unique Position to Face Crisis Research*. The CIRES/CU/NOAA cooperative efforts have a unique ability to solve short-term crisis research identified by NOAA scientists as well as the planned longer-range research projects.

■ *Efficient Use of Government Funding.* The CIRES/CU/NOAA cooperative effort provides efficient use of government funding to accomplish the joint NOAA/CIRES objectives through the ready availability of diverse scientists who can be drawn quickly into a new research effort on a given high priority project of NOAA.

■ *Strength of Boulder Scientific Community.* The unique nature of the Boulder Science Community which hosts CIRES, University of Colorado, and the various NOAA laboratories within close proximity, as well as the proximity of other National Laboratories (*e.g.*, NCAR), add a tangible value to the CIRES research efforts. The wealth of scientific talent available from this community is of special value in the development of plans to tackle a common, complex research problem.

■ *Strong Leadership.* The CIRES director, Susan Avery, has been an effective, enthusiastic and articulate leader within the university, at NOAA, and throughout the earth sciences community. The paradigm of CIRES' management seeks to be one of staff inclusion that provides a voice and forum for all CIRES staff. The system seems to work very well; staff morale within CIRES seems to be uniformly positive. The panel was greatly impressed by the strong support for CIRES/NOAA cooperative efforts shown by the Vice President for Research and Graduate School Dean, Carol Lynch.

■ *CIRES Research Planning.* Procedures and processes for determining the direction of the science in CIRES appear to be robust and have necessary checks and balances. .

■ *Block Funding to CIRES.* Block funding to CIRES provides some stability to the operation, and we believe that it is a major factor in the success that CIRES has shown.

■ *Change from Funding Individual Scientists to the Funding of Projects.* The panel believes that the new annual plan that will request funding for identified projects rather than for individuals will be a major improvement.

■ *The Innovative Research Program.* This program is excellent. It stimulates the initiation of new research and tests the feasibility of success of a potential research project before the detailed planning and launch of an expanded version of the new research effort.

■ *Importance of Visiting Fellows Program.* Visiting fellows who are selected from leading research groups around the World provide an important source of new ideas and creativity, and it is vital that this program be maintained.

■ *Student and Teacher Training in CIRES.* There is a very unique student training potential present in the CIRES/CU/NOAA cooperative research efforts which adds

greatly to its benefit to the community and the nation. The involvement of the agencies' personnel in the important processes in the education of K-12 students is an important product of the CIRES/CU/NOAA cooperative agreement. (See the further discussion of this topic in section IV-E.)

III. Suggested Areas that Require Attention in the Continuation of the CIRES/NOAA Research Effort

■ *Perceived and Real Differences in Status of Government Employees Versus CU Employees in the Laboratories.* CIRES/CU employees work along side NOAA employees in the NOAA laboratories. There are significant differences between the benefits and job security of the two groups. This has led to employees concerns about fairness. While current CIRES management is clearly aware of these issues, and has worked to ameliorate the differences, it is an issue that will require continued attention.

■ *Rigidity within CU.* The traditional mainline departments of the University do present formidable obstacles to startup of new interdisciplinary studies. However these departments are the important backbone of the University and will likely be maintained for many years. Among other virtues they help support the alumni base. New CIRES planning should try anew to obtain increased input from related department faculty to help strengthen the respect for the CIRES effort. Certainly the maintenance of high quality of the future CIRES research efforts will help to earn increased respect and attractiveness of CIRES for future joint research efforts with university departmental faculty.

■ *Contract Versus Grant Research.* The recent trend of shifting the relationship between NOAA and the cooperative institutes more toward contracts rather than grants is disturbing, and threatens to remove the vitality which this enterprise must have to be ultimately useful to society, and to retain the type and caliber of personnel needed. The process of transitioning from research to applications is itself an important area of intellectual inquiry, and amenable to rigorous examination as a research topic unto itself, every bit as complicated as the behavior of the climate system

■ *The Perception of CIRES and Funding Agencies.* The Panel believes that there may be an NSF prejudice against CIRES proposals to NSF perhaps because of the perception that they might be laundered NOAA proposals. Also it appears to some of the review Panel that recent NOAA management has become wary of outside-funded proposals, simply because they are now perceived as distracting NOAA researchers from providing the needed research support for NOAA's longer-term operations and services goals.

■ *Institutional Support for CIRES.* The NOAA laboratories have strong support for CIRES. Obviously, more could still be provided. NOAA could donate more leadership time to provide enhanced awards and recognition. There are greater issues with the CU faculty support, although the University Administration appears to be very helpful. CU

obviously has control over faculty and educational programs. CU has worked well with CIRES on the development of an interdisciplinary research program. More effort on the interdisciplinary education program should be granted. CIRES and CU leadership should continue to seek ways to encourage the CU faculty to embrace CIRES participation and activity. CU should play hire, inspire, and entrain non-CIRES faculty into CIRES activities.

■ *Is the translation from research to applications working?* Do we know the answer to this question? The panel feels that at least there is a successful start to this transition. The large number of diverse research groups within the CIRES/NOAA umbrella which are involved in the research within each CIRES research theme gives evidence of the interdisciplinary nature of the research. (See listing of "cooperating units" shown in sections IV-A to IV-F of this report.) But the extent to which significant interaction occurs between the diverse investigators in a given project remains unclear to the panel. CIRES should continue to develop new methods to judge the depth of such interactions and identify and attempt to remove the barrier problems that remain.

■ *Application of a Barriers Approach to CIRES/NOAA research*. A "barriers" approach should be applied for issues where "logic" suggests that all parties desire a certain outcome, but that outcome remains elusive. For interdisciplinary endeavors to be successful, the administrative framework must possess the same qualities of "boundary permeability" as the research topics.

■ *Additional staff in the biological area.* The contemplated extension into biology is an idea whose time has come. Biological systems are the epitome of complex systems, and indeed there is an increasing trend toward viewing the earth system as a living thing. See further discussion of this point in section IV-E.

■ *Reward System.* Until a few years ago there was no reward system for CIRES/CU employees. The director, Susan Avery, has made a start in implementing a system that recognizes a few (usually two) employees each year. We strongly assert that a much more extensive reward system, based on comparability with the federal system, is warranted for individual accomplishments or sustained performance by CIRES employees. These could be comprised of graduated cash awards ranging from $250 to $1000. We feel that this will result in improved employee morale and productivity at minimal cost. For example, a budget of $40,000 per year would allow recognition of 25% of all employees annually. (See also the discussion in section V-C.)

■ *Increase of Matching Funds.* The panel believes that matching funds, internal research funds, as well as the reward structure should be strengthened.

■ *Environmental Technology Center (ETC).* We encourage the serious consideration of the addition of this new unit. The significance of such a Center within CIRES and its potentially unique contribution to the study of the environment should be recognized by the CIRES/NOAA/CU administrations. See additional discussion of and justification for

the possible ETC unit in Section V-A of this report. Engineering centers of excellence and more major research instrumentation programs should be explored.

■ *Addition of new interdisciplinary areas of research.* Some panel members feel that addition of the important new area of research, Surface/Atmosphere Exchange, could make CIRES more effective and stable. This should be considered further by the CIRES policy committees.

■ *Additional Projects Inviting Stakeholders.* The Western Water Assessment Project appears to be one that relates most closely to stakeholders. This project illustrates an excellent attempt of the CIRES/NOAA staff to take research all the way through the application step. The WWAP has produced a meaningful annual schedule, which is not dependent on dates, but rather events, and CIRES is training the users in this. Is there enough involvement in similar research areas within CIRES? The panel suggests the development of additional programs for which close stakeholder-CIRES relationships are readily identified.

■ *Environmental Studies –CIRES Duplication*? Some members of the panel felt concern that the Environmental Studies program has mimicked CIRES and will compete and not complement the organization.

■ *Employee Handbook.* A CIRES employee handbook should be developed that describes the policies and procedures that apply to CIRES employees. This might be done as a stand-alone document or an addendum to the CU employees handbook.

■ *Joint Appointments and CIRES Leadership.* This is a significant area where CIRES could be made more effective and stable.

■ *Importance of Visionary Issues.* More attention should be given to the "visionary issues" as a group in the forefront of interdisciplinary research. The CIRES, NOAA, and CU scientists and their respective administrations should study the questions: How does one identify the next looming issues, just visible on the horizon? How does one position activities to be ready to tackle those effectively?

IV. Review of Some Specific Research Activities

In this brief review of the individual CIRES/NOAA research activities in this section, we have organized the observations, discussion, and recommendations under the stated CIRES Research Themes: *Advanced Observing and Modeling Systems; Climate System Variability; Geodynamics; Regional Processes; Climate System Variability; Integrating Activities; Planetary Metabolism;* and *Regional Process.* The quality of the research in each of the areas to which the panel was exposed is rated as very good to excellent. The limited length of this report restricts our comments to one or two examples in each area. Our omission of discussion of a given research report within any of these areas should

not be construed as a disapproval of its support. Where recommendations for change or improvement of certain efforts are suggested these will be spelled out.

A. ***Advanced Observing and Modeling Systems***.

Stated research goals: 1) To develop new measurement techniques; 2) to develop new instrumentation; 3) to advance theoretical understanding; and 4) to refine data management and analysis methods.

Cooperating units of CIRES and NOAA: CU-DCB, NOAA-AL, NOAA-ETL; NOAA-FSL; NOAA-SEC; CIRES-CSES; CIRES-NSIDC; PAOS, NOAA/CIRES-CDC; CU-DG; CU-DGS; CU-CEAS (Full names of laboratories and their acronyms used in this report are given in Appendix B.)

Related Review Panel Observations: Illustrative of the excellent work of the CIRES/NOAA teams in the development of specific instrumentation to aid in trace gas quantification in the atmosphere is the recent work on NO_3 and N_2O_5 using cavity ring-down spectroscopy. For the first time seemingly unambiguous estimates of the N_2O_5 concentration in the nighttime atmospheres have been possible through the control of the equilibrium, $N_2O_5 \leftrightarrow NO_3 + NO_2$, though choice of sample temperature during analysis. N_2O_5 is especially important since it is a precursor to HNO_3 formation (acid deposition, etc.). Also instrumentation designed to measure the common atmospheric trace gas, HNO_3 has been developed within CIRES/NOAA. Nitric acid is another very reactive and difficult trace gas to measure quantitatively. An excellent method has been developed in the CIRES/NOAA laboratories that appears to be highly specific and offers an important new tool for use by atmospheric scientists.

B. ***Climate System Variability (and Human Caused Climate Warming)***

Stated research goals: 1) Data collection and analysis; 2) observation, and modeling; and 3) forecasting.

Cooperating units of CIRES and NOAA: NOAA-CIRES-CDC; NOAA-CMDL; NOAA-AL; PAOS; CIRES-WWA; CIRES-NSIDC, NOAA-NCEP; NOAA-GFD

Related Review Panel Observations: Much of the CIRES/NOAA research in this area, which was described to us during the review, appears to offer a very important input to our understanding of the variability of climate, global warming, and the prediction of the effects to be expected from future changes in the climate on various regions of the earth. NOAA/CIRES scientists are working collaboratively on key aspects of climate variability and global warming. Prominent examples include: AL/CIRES leadership on the international global warming assessment (IPCC) and ozone assessment processes; CMDL/CIRES efforts on climate and chemical monitoring for anthropogenic change; CDC/CIRES/CU research advances on the predictability of seasonal/interannual climate temperature anomalies, as well as previously under-researched areas such as

predictability of seasonal/interannual precipitation anomalies, plus the potential predictability (or persistence) of continent-scale temperature anomalies on time scales of a year to a decade; and the FSL/CIRES effort to design a new long-term observing/monitoring system for improved daily-seasonal-interannual weather/climate forecasting and diagnosing long-term climate change for the 21st century

C. Geodynamics

Stated research goals: 1) To increase our knowledge of the fundamental processes that drive the mantle; 2) to use new experimental methods to detect and monitor internal motions of the mantle, the presence of layering, the movements of continents and the transfer of mass between atmosphere, continents and ocean; 3) to examine the chemistry and physics of near surface rock processes; 4) to investigate links between geophysical processes and human demographics.

Cooperating units of CIRES and NOAA: CU-GSD; CU-GP, CIRES-CCCC; NOAA-NGDC

Related Review Panel Observations: Two examples of work within CIRES present dramatic evidence of the continuing importance to the human environment on the earth's surface of processes within the solid earth. Studies of the earth's gravity field have made important observations from GRACE, a recently launched pair of satellites. Data from this satellite pair will enable detection of very small changes in the distribution of water, snow and ice. Their long-term goals are to resolve issues associated with accelerating sea level rise and the mass transfer of water from melting ice to the World's oceans. In more speculative research, some scientists in this CIRES study area have postulated that motion of tectonic plates may modulate major climate changes by altering oceanic circulation patterns. They present evidence that 3 to 5 million years ago the northward motion of New Guinea resulted in a change in Pacific Ocean circulation patterns and took the planet from a persistent El Nino state to its current state with only periodic El Ninos. (See also the discussion of this topic in section V-D.)

D. Integrating Activities:

Stated research goals: 1) To foster interdisciplinary cooperation; 2) to share knowledge; 3) to forge mutually beneficial partnerships; 4) to open strong lines of communication between CIRES and communities that can use environmental science.

Cooperating units of CIRES and NOAA: CIRES-K12POP; CIRES-CSTPR; CIRES-NSIDC; CIRES-WWA

Related Review Panel Observations: This research area appears to the panel to be an important piece of the organization that strengthens all of its parts. Of special interest to the panel is the K-12 POP research effort. The positive influence that the Outreach program has on the public is a most valuable product of CIRES. The Outreach program extends beyond K-12. The research and technology developed can be and has been

provided to such organizations as weather and climate services. This also facilitates more social science integration. We also recognize another of the excellent CIRES/NOAA programs in the social sciences as the Alaska project, in which Native coastal communities are involved directly in the project. CIRES is flexible and the science plan and mission can encompass NOAA's needs and mission. (See the further discussion of this topic in section V-E.)

The panel recognizes the great potential value of the new Center for Science and Technology Policy Research. Science and technology policy and impact assessment research is a critical component to a large fraction of CIRES' research activities. CIRES has recently strengthened its capabilities in this area with the establishment of a new Center for Science and Technology Policy Research with a new, well-qualified director.

E. Planetary Metabolism

Stated research goals: 1) To increase knowledge of the fundamental processes that drive the biosphere; 2), to use experimental tools to accurately measure indicators of change; 3) to enhance the sophistication of prognostic models capable of forecasting ecosystem and the global biosphere response to future environmental changes; 4) to carry out research that will develop science and technology to help us restore and protect the health of the biosphere.

Cooperating units of CIRES and NOAA: CIRES-CSES; CU-EPOB; CU-MCDB

Related Review Panel Observations: The panel wishes to stress the importance of biologic impact on the earth system and the need for a strong program within CIRES/NOAA. We note that attempts to add staff in this area have been hampered by problems with University of Colorado departments. We hope the current plan will be more effective and results in these staff additions. (See the additional panel discussion of this topic in section V-A.)

CIRES research ranges from obviously important areas such as carbon flux from Colorado sub-alpine forests and carbon and nitrogen relationships in western rangelands, information which is important to understanding carbon sequestration. The quality of this research is outstanding, and CIRES is at the forefront of technology in measuring these exchanges. The work is timely, since the information is urgently needed to effectively incorporate these biological aspects into the climate models.

Work on nitrogenous compounds also is very important. The release and utilization of nitrogen into and from the atmosphere is an important topic, and also work on the release and uptake of organic nitrogen by trees is both innovative and important. A notable achievement has been the development of a new technique for measuring denitrification. Although a large proportion of the product release to the atmosphere is likely to be molecular nitrogen, under some conditions the products are nitrogen oxides, which are important greenhouse gases and can contribute to ozone formation in the troposphere. On

the other side of the picture, application of this methodology will also provide information on the loss of nitrogen from the biosphere. The fate and transport of carbon and nitrogen is being addressed well by the CIRES programs, and the studies are providing state-of-the art information on their sequestration and release. Greenhouse gases and pollutants are being addressed effectively.

The current biology program is conducting excellent research that feeds directly into the climate prediction mission. The program is large scale as well as regional. Its expansion with additional carefully selected expertise is reasonable, and hopefully negotiations with departments can result in successful hires in the future. Studies of the Greenland ice sheet and arctic ecosystem effects are important, high quality contributions and of high relevance to global processes.

F. Regional Processes:

Stated research goals: 1) Region-specific impacts of climate variability and extreme events; 2) regional hydrological cycles in weather and climate; 3) surface atmosphere exchange; 4) regional air quality; 5) intercontinental transport and chemical transformation; 6) atmospheric chemical forecasting; 7) high latitude/high altitude regional processes.

Cooperating units of CIRES and NOAA: CIRES-CSTPR; CIRES-WWA; NOAA-AL; NOAA-ARL; NOAA-FSL; NOAA-CIRES-CDC

Related Review Panel Observations: The NOAA/CIRES team efforts related to the Houston and New England regional air quality studies give definitive evidence of the nature of the pollution seen, origin of this pollution, and a first cut at how we might best correct these problems. Truly these two outstanding studies will provide a most significant input to the solution of these very long-standing and important problems.

Basic and applied environmental research is required to understand how natural and anthropogenic factors are and will influence the earth system. Biosphere coupling is a common thread in CIRES research activities. Unarguably, CIRES is a leader in oceanic and terrestrial boundary layer meteorology, atmospheric trace gases, and the carbon cycle. The CIRES program on regional process studies integrates the talents and resources from CU and the different NOAA laboratories. There is particularly creative synergy in CIRES amongst the ARL, ETL, and CMDL laboratories. These process studies have been efficient at applying CIRES basic and innovative research tools that are essential for the missions of NOAA. A basic, process level understanding of surface/atmosphere exchange is needed for weather and climate forecasting. CIRES houses the infrastructure to provide physical, chemical, and environmental tools to address atmospheric chemical transformations, the hydrological cycle, and the carbon cycle. It also includes earth's terrestrial and marine ecosystem.

V. Issues Related Specifically to the Future Structure and Administration of CIRES

A. *Enhancement of the Biological Science Staff of CIRES*

CIRES has made excellent progress in addressing climate and water issues, and has started to move into related biological areas. The panel finds this entirely appropriate, since an understanding of the earth system requires coverage of the metabolic processes, which strongly influence the composition of the earth's surface and the atmosphere.

The current cadre of biologists on the CIRES faculty is small—only four FTEs. The program as it is developing has identified a need for up to four additional faculty. The first question to be answered, however, is whether the current biological research is of high quality and whether the direction being taken is appropriate for CIRES. The research in the area of Planetary Metabolism addresses the processes that drive the biosphere. The influence of biological processes and their response to climatic change is fundamental to any large-scale program addressing climate. In this regard, the thrust being taken by CIRES appears to be appropriate. It also is timely, in that most of the models to date have not been able to address the living component adequately due to a lack of understanding.

The biology program should be a CU/CIRES issue. It fits more in the environmental studies program. NOAA laboratories should continue to take advantage of this research area and enhance inputs from it. Environmental biology is an essential component to the forecasting the health of our ecosystem. It is evident that CIRES fellows are cognizant of the desire for strength in this area. Research in some areas within CIRES has actively encouraged input from biologists. For example, in many of the field studies of regional atmospheric transformations and transport carried out by CIRES/NOAA scientists, the tree and plant emissions of the biologically important compounds such as isoprene, the terpenes, and various oxygenated organic species were determined. The biology which controlled their formation and the magnitude of the fluxes were included as important inputs to the studies. However, in the opinion of the reviewers, many of the physical and chemical research efforts that exist currently in CIRES do not embrace completely the interdisciplinary aspects of biology.

B. Addition of an Environmental Technology Center within CIRES

CIRES fellows are considering a proposal to establish an Environmental Technology Center (ETC) within CIRES. The ETC would have as its goal the identification and development of innovative environmental technology measurement systems, observing strategies, applications products and so forth. The focus would be on medium- and long-range developments rather than short-term incremental environmental measurement solutions. A few examples might include nanotechnology-based chemical sensors, MIMS technologies, use of autonomous aerial vehicles, advanced lidar systems, networkable low-cost and low-power multi-parameter radars, and so forth. A CIRES ETC is a logical and powerful extension of expertise already resident within CIRES,

NOAA/OAR and the university. Such an addition would also have significant benefit because of the close geographical proximity to other expert institutions in the Boulder area: NCAR, NIST, CSU and private companies such as Ball Aerospace, Coherent Technologies, and Vaisala, to name a few. Furthermore, an ETC is important to NOAA and the nation because of the general decline in research devoted to advanced atmospheric measurement solutions and the corresponding decline in the pool of available scientists and engineers trained in advanced environmental measurement technologies and their application. The applications of these technologies are both very important and inherently interdisciplinary (e.g. climate processes, hydrology, emergency response), thus making an ETC inherently consistent with CIRES mission. The panel strongly recommends that CIRES go forward with its proposal, and that NOAA OAR and CU vigorously support the establishment of an Environmental Technology Center.

C. Cooperative Agreement Structure

A fundamental precept of the cooperative agreement is the research partnership between NOAA and CIRES scientists. It is critical that future work be allowed to continue in a truly collaborative spirit. The panel recommends that the current agreement construct be continued and that proposed changes to a contract basis be discouraged. Further, the panel encourages NOAA and CIRES to explore ways to streamline the current process of identifying and funding tasks in a way that will lead to a reduced administrative burden and greater efficiency. (For example, in the current fiscal year about $17M were expended across approximately 200 individual tasks).

C. *Staff Recognition and Compensation*

One of the key elements to the successes of CIRES is the close collaboration among the scientists and support staff at NOAA and CIRES. In many cases, CIRES staff work in close geographical proximity to NOAA staff, being resident in some cases in NOAA facilities. The OAR laboratory directors are commended for their active efforts to promote equal recognition and treatment of CIRES staff who are collaborating with NOAA staff. However, there is the danger that CIRES staff may not receive comparable compensation as their NOAA collaborators. Compensation discrepancies have led to substantial morale problems for CIRES scientists, thus threatening the effectiveness of the collaborative process. The problem arises because the Federal government and the University have different annual salary adjustment practices. The University should explore ways to avoid a NOAA-CIRES compensation gap, while ensuring that CIRES staff compensation is consistent with CIRES' university peers. NOAA should also explore ways to recognize CIRES staff who have collaborated with award-winning NOAA staff (and vice versa). To the extent possible, award recognition should be transparent of the host institution.

D. The Importance of a Strong Geodynamics Component within CIRES

We feel it is important to maintain a strong Geodynamics component within CIRES. Processes within the solid earth form an important boundary condition for events in the atmosphere. In some cases the interaction can be very obvious as when volcanic eruptions inject gases and particulate matter into the atmosphere. The record suggests that in the past such events have had major impacts on the habitability of the planet. We note that the Geodynamics group has recently lost two faculty members. Without commenting on the specific need to replace these staff losses, we believe that attention should be paid to maintaining the long-term health of this component of CIRES. The solid earth is a major component of the earth system. Understanding the interaction between the earth's solid and fluid phases is critical to advancing CIRES stated mission to provide an environment for "understanding the earth system".

E. Enhanced Role of the Integrated Activities Programs

The positive influence, which the Outreach program has on the public, should be strengthened where possible. Perhaps the use of the staff as a clearinghouse for all useful educational materials on the environment which are now available from known sources could be catalogued, and advertised to educational institutions at all levels. The scientific staff presumably would recommend to the public only those materials which have been thoroughly reviewed by them and found to be useful and as scientifically accurate in their detail as current knowledge allows. There is more that CIRES can and needs to do in this area, and it is well posed to work on NSF and NASA outreach as well.

As CIRES considers expanding its expertise in biology and environmental technology, the panel recommends that CIRES also consider the possible need for expansion of the policy research and assessment activities of the institute. The panel did not review the balance between current and future needs and the current resources in these areas, but encourages CIRES administration and the Fellows Council to examine the need and establish priorities for possible expansion in all three areas.

F. NOAA Legal Review Implications?

The current effort of NOAA to clarify and standardize the definitions of “Contract”, “Cooperative”, and “Grant” terminology for contracts, cooperative agreements and grants across all 11 joint institutes is a healthy and helpful plan. However, we feel that care must be taken to insure that allowance is made for potential differences within the individual laboratories.

G. Is the Organization by Scientific Research Themes an Effective Structure for CIRES?

In the opinion of the panel, this is an effective way to approach interdisciplinary research and maximize available staffing and resources.

H. Should Different Models for the Organization of CIRES be Considered?

Although there are some difficulties with the current model (see earlier comments of the structure of the cooperative agreement), the panel is of the opinion that there are no obvious models that provide a superior alternative.

VI. Summary of Panel Recommendations to NOAA and CIRES Management

1) In view of the high quality of the research and the significant past success of the CIRES/CU/NOAA cooperative research efforts, retain the current format of the cooperative agreement with block funding of identified projects in contrast to the less responsive and less efficient contract oriented structure.

2) Retain and strengthen the current program structure which features outstanding administrative leadership and encourages participation of all active employees.

3) Innovative Research and Visiting Fellows programs should be continued and strengthened.

4) Expand the policy research and assessment activities of the new Center for Science and Technology Policy Research as CIRES considers expanding its expertise in biology and environmental technology.

4) Continued attention should be given to the perceived relative status of CIRES and NOAA personnel.

5) There should be continued and strengthened efforts of the administration, scientific staff and faculty to moderate the rigidity within the university faculty and department structure so that formidable obstacles to startup of new interdisciplinary studies involving the university faculty are minimized.

6) Add to CIRES additional biological scientists to fill the gap in representation and input from this increasingly important area.

7) Restudy the employee award system to recognize a greater fraction of those doing outstanding work.

8) Establish a new Environmental Technology Center within CIRES.

9) Prepare an employee handbook for CIRES personnel.

10) Continue the current Outreach programs and consider expansion of its activities to serve as a clearinghouse for selecting and recommending the use of scientifically accurate classroom materials and public information related to environmental problems.

Appendix A. Schedule of the Panel during the CIRES/NOAA Review

CIRES Review -September 25-27,2002

September 25, 2002 (Day 1)

Agenda	Time	Location	Notes
Breakfast - Panel/NOAA	7:30-8:30	Broker Inn	Panel charge and discussion Transportation available from hotel
Plenary Session ○ Welcome/Intro ○ Overview	8:30-9:30	CIRES Auditorium	Led by Susan Avery
Break	9:30-10:00	CIRES 340	
1st Poster Session	10:00-12:00	2nd floor Ekeley, CIRES	
Lunch	12:00-1:30	TBD	Avery/Review Team
2nd Poster Session	1:30-3:30	2nd floor Ekeley, CIRES	
Executive Committee Session	3:30-4:30	Ekeley S274	Poster Session Review and discussions with Exec Committee and Panel.
NOAA Lab Directors	4:30-5:30	Ekeley S274	Lab Directors and Panel
Panel Executive Session	5:30-6:30	Ekeley S274	
Dinner	6:30	TBD	Panel alone. Transportation available at any time.

September 26, 2002 (Day 2)

Full Breakfast with Dep't. Chairs	8:00-9:00	CIRES 340	Transportation available. Panel with current, incoming, outgoing dept. chairs
Council of Fellows	9:00-10:30	Ekeley S274	Fellows and Panel
Break	10:30-11:00		
Interview: CU Leadership	11:00-11:30	CIRES 305	Lvnch and Panel
Working Lunch: Mgmt. Issues, Koch, Pierce, Uhart, Lync,h, panel, Avery, Moll, Walloch, Kosle, Sperry, new AD, SAB	11:45-1:30	Ekeley S274	Review of management issues
Interview: NOAA Leadership	1:30-2:00	CIRES 305	Koch, Uhart, Callender, and Panel
Members Council	2:15-3:15	Ekeley S274	Member's Council and Panel
Break	3:15-3:30		
Panel Deliberations	3:30-5:00	Ekeley S274 or hotel?	Transport back to Broker available at any time

September 27, 2002 (Day 3)

Writing Session	8:00-1 1:00	Ekeley S274=	Continental breakfast. Transportation and computers available
Panel Feedback	11:00-12:00	Ekeley S274	Exec. Committee/Panel
Lunch		On your own	
CIRES 35th Anniversary Party	2:00-5:00	Old-Main Chapel &, Quad	Transportation available after party

Appendix B. Definition of the Acronyms Used in This Report

CIRES = University of Colorado Cooperative Institute for Research in Environmental Sciences
CIRES-CCCC(C4) = Colorado Center for Chaos and Complexity
CIRES-CSES = Center for the Study of Earth from Space
CIRES-CSTPR = Center for Science and Technology Policy Research
CIRES-K12POP = K-12 and Public Outreach Program
CIRES-NSIDC = National Snow and Ice Data Center
CIRES-WWA = Western Water Assessment
CU = University of Colorado Boulder
CU-CEAS = College of Engineering and Applied Sciences
CU-DCB = Department of Chemistry and Biochemistry
CU-DG = Department of Geography
CU-DGS = Department of Geological Sciences
CU-EPOB = Environmental, Population, and Organismic Biology Department
CU-GP = Geophysics Program
CU-GSD = Geological Science Department
CU-MCDB = Molecular, Cellular, and Developmental Biology Department
ETC = Environmental Technology Center
GRACE = NASA's Gravity Recovery And Climate Experiment
FTE = Full-time equivalent faculty
FSL = Forecast Systems Laboratory of NOAA
IPCC = Intergovernmental Panel on Climate Change
K-12 = Kindergarten to twelfth grade
NASA = National Aeronautics and Space Administration
NCAR = National Center for Atmospheric Research
NOAA = National Oceanic and Atmospheric Administration
NOAA-AL = Aeronomy Laboratory
NOAA-ARL = Air Resources Laboratory
NOAA-CIRES-CDC = Climate Diagnostic Center
NOAA-CMDL = Climate Monitoring and Diagnostic Laboratory
NOAA-ETL = Environmental Technology Laboratory
NOAA-FSL = Forecast Systems Laboratory
NOAA-GFD = Geophysical Fluid Dynamics Laboratory
NOAA-NCEP = National Center for Environmental Products
NOAA-NGDC = National Geophysical Data Center
NOAA OAR = NOAA Office of Oceanic & Atmospheric Research
NOAA-SEC = Space Environment Center
NSF = National Science Foundation
PAOS = Program in Atmospheric and Oceanic Sciences
WWAP = Western Water Assessment Project